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Organizational Form and Efficiency: An Analysis of Stock and Mutual Property-Liability Insurers

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Organizational Form and Efficiency: [1]
An Analysis of Stock and Mutual Property-Liability Insurers

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Abstract : This paper analyzes the efficiency of stock and mutual organizational forms in the property-liability insurance industry using nonparametric frontier efficiency methods. We test the managerial discretion hypothesis, which predicts that the market will sort organizational forms into market segments where they have comparative advantages in minimizing the costs of production, including agency costs. Both production and cost frontiers are estimated. The results indicate that stocks and mutuals are operating on separate production and cost frontiers and thus represent distinct technologies. The stock technology dominates the mutual technology for producing stock output vectors and the mutual technology dominates the stock technology for producing mutual output vectors. However, the stock cost frontier dominates the mutual cost frontier for the majority of both stock and mutual firms. Thus, the mutuals' technological advantage is eroded because they are less successful than stocks in choosing cost-minimizing combinations of inputs. The finding of separate frontiers and organization specific technological advantages is consistent with the managerial discretion hypothesis, but we also find evidence that stocks are more successful than mutuals in minimizing costs.

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ORGANIZATIONAL FORM AND EFFICIENCY: AN ANALYSIS OF STOCK AND MUTUAL PROPERTY-LIABILITY INSURERS

1. Introduction

In the modern theory of the firm, agency costs provide an explanation for the structure of organizations, with the organizations that survive in any economic activity being the ones that deliver the desired product at the lowest possible price while covering agency costs and the costs of production (e.g., Jensen and Meckling, 1976, Fama and Jensen, 1983a, 1983b).[1] The insurance industry provides an interesting environment for studying the agency theoretic hypotheses because different organizational forms coexist in the industry. This paper focuses on the two most important organizational forms in the property-liability insurance industry -- stock insurers, which are owned by shareholders, and mutual insurers, which are owned by policyholders.[2] The objective is to test hypotheses regarding the relative efficiency of the stock and mutual organizational forms using nonparametric frontier efficiency methods.

Agency theory arguments have led to the development of several hypotheses about the stock and mutual organizational forms. These stem from the observation that the two organizational forms have comparative advantages in dealing with different types of agency costs. The stock ownership form provides more effective mechanisms for controlling owner-manager conflicts than the mutual ownership form. Stock firms have alienable ownership claims, giving rise to control mechanisms such as proxy fights, hostile takeovers, and executive stock option plans that can be used to reduce opportunistic behavior of managers. Because mutuals do not have alienable ownership claims, the control mechanisms available to mutual owners are much weaker. On the other hand, the owner-policyholder conflict is likely to be relatively high in the stock ownership form because stockholders have an incentive to expropriate value from policyholders by taking

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[1]With costly contracting, agency costs are generated by incentive conflicts among parties to a contract (Jensen and Meckling, 1976). Agency costs are defined as all costs incurred in attempting to control agency conflicts as well as the residual costs that remain because the costs of full enforcement of the contract exceed the benefits.

[2]Stocks and mutuals together account for about 93 percent of property-liability insurance premium revenues. The other two organizational forms in the industry are reciprocals, which are somewhat similar to mutuals, and Lloyds associations, where the ownership and management functions are merged. See Mayers and Smith (1986).

actions such as delaying claim payments and changing the risk-characteristics of the firm after policies have been issued. Mutuals deal effectively with the owner-policyholder conflict by merging the ownership and policyholder functions.

Perhaps the most influential agency theoretic hypothesis about stocks and mutuals is the *managerial discretion hypothesis* (e.g., Mayers and Smith, 1981, 1986, 1988). According to this hypothesis, the degree of managerial discretion required to operate in a given line of insurance is the primary determinant of the organizational form likely to succeed in that line. The hypothesis predicts that the stock ownership form will be dominant in lines of insurance where managers must be given a relatively large amount of discretion in pricing and underwriting, such as such as commercial coverages on national or multi-national firms, and in operating over wider geographical areas. The stock form of ownership is likely to have a comparative advantage in these types of operations because of its superior mechanisms for owners to control managers.[3] Mutuals, on the other hand, are likely to be more successful in lines that require less managerial discretion such as personal lines, where the need for individualized pricing and underwriting is relatively low. Where managerial discretion is limited, the elimination of the owner-policyholder conflict is likely to give mutuals a comparative advantage over stocks.[4] The same reasoning leads to the prediction that mutuals are likely to be relatively successful in lines such as liability insurance, where claims settlement may occur several years after the policy is issued, because the longer time horizon gives managers more opportunity to exploit policyholder interests. This is known as the *maturity hypothesis*.

Because the available mechanisms for controlling owner-manager conflicts in the mutual ownership

[3]Evidence consistent with the managerial discretion hypothesis has been provided in numerous papers (see, for example, Mayers and Smith, 1988, 1992).

[4]Mutual insurers thus should be relatively successful in lines of business with relatively good actuarial tables and lines where underwriting procedures and reinsurance decisions are relatively uncomplicated. In general, mutuals also should engage in fewer lines of business and operate over narrower geographical areas than stock insurers, because the costs of monitoring and controlling management varies directly with the scope of an insurer's operations.

form are relatively weak, the costs of managerial opportunism in the mutual ownership form are expected to be higher than in the stock ownership form. One potentially important type of managerial opportunism is "expense preference" behavior, where managers generate unnecessary costs through the consumption of perquisites (e.g., Williamson, 1963). According to the *expense preference hypothesis*, mutuals are expected to be less successful than stocks in minimizing costs because of higher perquisite consumption.

It is important to point out that these hypotheses are not mutually exclusive; e.g., it would be possible for mutuals to be more successful in low managerial discretion or longer-maturity lines of insurance, even though mutual managers exhibit expense preference behavior. This outcome would imply that the perquisite consumption is not sufficient to offset the mutual advantage in eliminating the policyholder-owner conflict.

The managerial discretion and maturity hypotheses predict that firms with different organizational forms will be sorted into market segments where they have comparative advantages in minimizing production and agency costs. According to this hypothesis, one would not necessarily observe differences in efficiency among organizational forms after controlling for production technology and business mix. The expense preference hypothesis, on the other hand, predicts that mutual firms will have higher costs than stock firms after controlling for business mix and other factors.

The purpose of this paper is to test these agency theoretic hypotheses by using frontier efficiency methodologies to compare the efficiency of stock and mutual property-liability insurers. Our analysis is based on non-parametric, “best practice” production and cost frontiers estimated for a sample of 211 mutual and 206 stock insurance companies over the period 1981-1990. We use data envelopment analysis (DEA) (see Charnes, et al., 1994) to estimate production and cost frontiers and Malmquist indices (e.g., Grosskopf, 1993) to measure the evolution of productivity and efficiency over time.

The fundamental idea behind our hypothesis tests is that the stock and mutual organizational forms represent different technologies for producing insurance, where technology is defined as including all of the contractual relationships that constitute the firm as well as physical technology choices. Thus, if the managerial discretion and maturity hypotheses are correct, stocks and mutuals should be operating with different production and cost frontiers. Furthermore, the stock technology should dominate the mutual technology for producing stock output vectors; and the mutual technology should dominate the stock technology for producing mutual output vectors. If the expense preference hypothesis is correct, mutuals are expected to be less successful than stocks in minimizing costs.[5]

The remainder of the paper is organized as follows: The hypotheses, empirical predictions, and methodology are discussed in section 2. Section 3 discusses input and output measurement and sample section. The results are presented in section 4, and section 5 concludes.

2. Hypotheses and Methodology

In this section, we briefly review the relevant prior efficiency literature on the insurance industry. We then discuss our hypotheses and methodology.

Prior Literature

In spite of the level of interest in organizational form in insurance, the literature on the efficiency of stock and mutual insurers is surprisingly sparse. The principal papers to deal directly with this issue using modern frontier efficiency methods are Fecher, et al. (1993), Gardner and Grace (1993), and Fukuyama (1997). Gardner and Grace (1993) analyze U.S. life insurers and conclude that efficiencies do not differ by organizational form; and Fecher, et al. (1993) arrive at a similar conclusion for the French insurance industry. The study most similar to ours in terms of methodology is Fukuyama (1997). Using DEA and the Malmquist approach, he finds that Japanese stock and mutual life insurers are operating on different production frontiers.

Our analysis extends the prior literature by providing the first frontier efficiency analysis of alternative organizational forms in the U.S. property-liability insurance industry. Our study extends Fecher, et al. (1993) and Fukuyama (1997) by analyzing cost efficiency as well as technical efficiency, measuring the efficiency of

[5]An additional advantage of the mutual ownership form, which we cannot test for our sample period, is that mutuals are less likely to respond to infrequent regulatory and other changes in a way that transfers wealth between owners and managers. E.g., Lee, Mayers, and Smith (1997) find that stocks changed their asset structure significantly to take more risk in response to the adoption of insurance guaranty funds, whereas the response of mutuals was much less pronounced. Thus, mutuals have some advantages in dealing with unusual events that are not measured in our analysis.

stocks and mutuals relative to the other group's production and cost frontiers (cross-frontier analysis), and explicitly testing the managerial discretion and expense preference hypotheses.[6]

Hypothesis Test Procedures

As mentioned above, the managerial discretion and maturity hypotheses predict that stocks and mutuals represent different technologies for producing insurance and, therefore, that stocks and mutuals are expected to operate on different frontiers. Furthermore, if these hypotheses are correct, then the stock and mutual technologies should be respectively superior in producing stock and mutual output vectors. The expense preference hypothesis predicts that mutuals will be less successful than stocks in minimizing costs. We test the hypotheses by estimating "best practice" production and cost frontiers. The production frontier represents the minimum quantity of inputs needed to produce a given output vector; while the cost frontier represents the minimum costs required to produce a given output vector, conditional on input prices.

We first test the null hypothesis that stock and mutual insurers are operating on the same frontier against the alternative hypothesis that they operate on different frontiers. Rejection of the null hypothesis in this case would be consistent with the managerial discretion and maturity hypotheses in that it supports the view that the two groups of firms are using different technologies. The rejection of the null hypothesis on this set of tests also would carry the implication that a comparison of efficiencies based on the pooled frontier is not informative because the two groups of firms are operating on separate frontiers. Because this null hypothesis is rejected (see below), we do not present a separate analysis of the pooled frontier.

To provide more direct information on the hypothesis that firms are sorted into groups with comparative efficiency advantages, we conduct a second set of tests. In this set the null hypothesis is that each group's output vector could be produced with equal efficiency using the other group's production technology. This involves computing the efficiency of the firms in each group with reference to the other group's

[6]Previous applications of non-parametric efficiency analysis to non-insurance financial institutions include Elyasiani and Mehdian (1992), who conclude that minority-owned banks and non-minority-owned banks have different production technologies.

production or cost frontier. Rejection of this null hypothesis for both groups would imply that stocks and mutuals have developed dominant technologies for producing their respective output vectors. This would provide evidence in favor of our efficiency-based interpretation of the managerial discretion and maturity hypotheses. This set of tests permits us to provide evidence on which frontier is dominant for each observation in the sample by measuring the distance between the stock and mutual frontiers for each firm's vector of inputs and outputs.

Measuring both production and cost frontiers provides evidence on the expense preference hypothesis by separating the effect on costs of the choice of production technology from the choice of input mix, conditional on the technology.[7] Even if stocks and mutuals are sorted into market segments where they have technological advantages, such advantages could be eroded if firms fail to choose cost- minimizing combinations of inputs, an outcome that has been interpreted as evidence of expense preference behavior (Mester, 1991). Expense preferencing could coexist with the sorting of firms into efficient groups based on technology. For example, mutual managers could consume higher costs up to the point where the mutuals' cost advantage over stocks due to their superior technology is nearly eliminated.[8]

The third part of our analysis, which looks at the evolution of efficiency and productivity over time, also sheds light on the expense preference hypotheses. The use of Malmquist indices permits us to separate the evolution of productivity into technical efficiency change and technical change. We analyze this evolution separately for the stock and mutual segments of the industry. If mutual managers have less incentive to operate efficiently, the inter-temporal performance of mutuals is likely to be inferior to that of stocks with

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[7]The Farrell cost efficiency analysis conducted here decomposes *cost efficiency* (i.e., the ratio of the minimum costs the firm could have realized by operating on the efficient cost frontier to the actual costs incurred) into *technical efficiency*, a measure of the distance of the firm from the efficient production frontier reflecting the most efficient technology, and *allocative efficiency*, a measure of the firm's success in choosing the cost-minimizing combination of inputs, conditional on its choice of technology.

[8]This type of outcome would require some limitation on competition within the mutual segment of the industry that permits the survival of inefficient firms, at least for some period of time. Evidence of maintained differences in efficiency over time in insurance and banking are provided by Cummins and Weiss (1993) and Berger and Humphrey (1991, 1992).

regard to either technical efficiency change or technical change.

Methodology

In this section, we provide an overview of our method for estimating production and cost frontiers and then discuss the linear programming problems that are solved to estimate efficiency and the Malmquist indices.

Distance Functions and Efficiency. To analyze production frontiers, we employ the input-oriented distance function introduced by Shephard (1970). Suppose producers use input vector $x = (x_1, x_2,\dots x_k)^T \in \mathbb{R}_+^k$ to produce output vector $y = (y_1 , y_2 , \dots y_n)^T \in \mathbb{R}_+^n$, where T denotes the vector transpose. A production technology which transforms inputs into outputs can be modeled by an input correspondence $y \rightarrow V(y) \subseteq \mathbb{R}_+^k$. For any $y \in \mathbb{R}_+^n$, V(y) denotes the subset of *all* input vectors $x \in \mathbb{R}_+^k$ which yield at least y. V(y) is assumed to satisfy certain axioms (see Färe, Grosskopf, and Lovell, 1985, and Färe, 1988). The input oriented distance function for a specific decision making unit (DMU) is defined by

$$\begin{aligned} D(y,x) &= sup\{ \theta : (y, \frac{x}{\theta}) \in V(y) \} \\ &= (inf\{ \theta : (y, \theta x) \in V(y) \})^{-1} \end{aligned} \tag{1}$$

The input distance function is the same as the reciprocal of the minimum equi-proportional contraction of the input vector x, given outputs y, i.e., Farrell's measure of input technical efficiency T(y,x), where T(y,x) = 1/D(y,x). The quantity D(y,x) must be $\geq$ 1, and T(y,x) is $\leq$ 1.

Distance functions can be estimated with respect to frontiers characterized by constant returns to scale (CRS), variable returns to scale (VRS), and non-increasing returns to scale (NIRS). In this paper, we work exclusively with CRS frontiers. This is the approach used most commonly in the literature because it represents the optimal outcome from an economic perspective, i.e., with CRS, firms are not consuming unnecessary resources because they are too large or too small (Aly, et al., 1990). The CRS approach measures departures from optimal scale as inefficiency.

We can also define a minimum cost function or cost frontier using the distance function approach (Farë, 1988, Lovell, 1993). Let $w = (w_1, w_2, \dots, w_K)^T$ denote the input price vector corresponding to the input vector x. Then the cost frontier is defined as:

$$c(y,w) = \min_x \{ w^T x : D(y,x) \geq 1 \} \qquad \textbf{(2)}$$

where c(y,w) = the cost frontier. The optimal input vector x^* minimizes the costs of producing y given the input prices w. Cost efficiency is calculated as the ratio $\eta = w^T x^* / w^T x$, where x represents actual input usage. The measure of cost efficiency, $0 < \eta \leq 1$, is interpreted as the proportion by which the firm could multiply its cost vector and still produce no less of any output.

The Malmquist index approach is used to measure technical efficiency change and technical change. Technical efficiency refers to the reciprocal of the distance from the production frontier and technical change refers to movements in the frontier over time. To define the Malmquist index for the production frontier, we modify equation (1) to incorporate time and define input distance functions with respect to two different time periods, as follows:

$$D^t(y^{t+1}, x^{t+1}) = sup\{ \theta : (y^{t+1}, \frac{x^{t+1}}{\theta}) \in V(y^t) \} \qquad \textbf{(3)}$$

$$D^{t+1}(y^t, x^t) = sup\{ \theta : (y^t, \frac{x^t}{\theta}) \in V(y^{t+1}) \} \qquad \textbf{(4)}$$

In equation (3), the input-output bundle in time period t+1 is evaluated relative to the technology of time period t; while in equation (4) the input-output bundle observed in period t is evaluated relative to the technology of time t+1. Malmquist productivity indices can be defined relative to either the technology in period t or the technology in period t+1, as follows:

$$M^t = \frac{D^t(y^t, x^t)}{D^t(y^{t+1}, x^{t+1})} \quad or \quad M^{t+1} = \frac{D^{t+1}(y^t, x^t)}{D^{t+1}(y^{t+1}, x^{t+1})} \qquad \textbf{(5)}$$

where M^t measures productivity growth between periods t and t+1 using the technology in period t as the reference technology, while M^{t+1} measures productivity growth with respect to the technology in period t+1. To avoid an arbitrary choice of reference technology, the input-oriented Malmquist productivity index is defined as the geometric mean of M^t and M^{t+1}:

$$M(y^{t+1},\ x^{t+1},\ y^t,\ x^t) = [(\frac{D^t(y^t,\ x^t)}{D^t(y^{t+1},\ x^{t+1})})\ (\frac{D^{t+1}(y^t,\ x^t)}{D^{t+1}(y^{t+1},\ x^{t+1})})]^{\frac{1}{2}} \quad \textbf{(6)}$$

This productivity index can be decomposed into measures of technical efficiency change and technical change, by factoring as follows:

$$M(y^{t+1}, x^{t+1}, y^t, x^t) = (\frac{D^t(y^t, x^t)}{D^{t+1}(y^{t+1}, x^{t+1})})\ [(\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^t(y^{t+1}, x^{t+1})})(\frac{D^{t+1}(y^t, x^t)}{D^t(y^t, x^t)})]^{\frac{1}{2}} \quad (7)$$

The first ratio in equation (7), in parentheses, represents technical efficiency change, i.e., the relative distance of the input-output bundle from the frontier in periods t and t+1. Recall that both the numerator and denominator of the ratio must be ≥ 1 and that values closer to 1 represent higher efficiency. Thus, if technical efficiency is higher in period t+1 than in period t, the value of this ratio will be > 1; while if efficiency declines between the two periods, the value of the ratio will be < 1.

The second factor in equation (7) is a geometric mean, representing technical change (shifts in the frontier) between periods t and t+1. If technical improvement occurs, the frontier will shift in a favorable direction, and both ratios comprising the geometric mean will exceed 1. Thus, values of the second factor > 1 imply technical progress and values < 1 imply technical regress.

To test the hypotheses investigated in this study, we need to estimate distance functions for stock and mutual insurers with respect to several different reference sets. In the following discussion, subscripts on D indicate the reference set of firms used to construct the frontier. E.g., $D_s(y_s, x_s)$ denotes the input distance function for stock firm s, measured with respect to a reference frontier consisting only of stock firms, where s = 1, 2, . . ., S, and S = the total number of stock firms in the sample. Likewise, $D_m(y_m, x_m)$ represents the input distance function for mutuals, where m = 1, 2, . . ., M, and M = the number of mutual firms. The pooled frontier with respect to the reference set consisting of all stock and mutual firms is denoted $D_p(y_i,x_i)$, i = 1, 2, . . . , M+S.

We also use a method originating from the Malmquist index approach, which involves computing distances of mutuals from the stock frontier and distances of stocks from the mutual frontier, i.e., each group of firms is used as the reference set for the other group. This method requires the estimation of *cross-frontier* distance functions:

$$D_m(y_s, x_s) = sup\{\theta : (y_s, \frac{x_s}{\theta}) \in V(y_m)\},\ s = 1,2,\ldots,S \quad \textbf{(8)}$$

I.e., $D_m(y_s,x_s)$ is the input distance function for stock firm s relative to mutual frontier. The input distance function for mutual firm m relative to the stock frontier, $D_s(y_m,x_m)$ is defined similarly. This enables us to measure the efficiency of the firms with a particular organizational form relative to a best practice frontier based on the alternative organizational form.

Whereas the distance function values for firms relative to their own group must be $\geq$ 1, the distances relative to the other group's frontier can be >, =, or < 1. This is illustrated in Figure 1, which shows isoquants for two hypothetical firms producing a single output with two inputs. The isoquant for stocks is labeled $L^S(y)$, and the isoquant for mutuals is labeled $L^M(y)$. The isoquants represent the best technology for the respective groups of firms, i.e., firms operating on the isoquants are on the production frontier and thus are fully efficient (T(y,x) = 1). To illustrate the group-specific frontiers, consider stock firm s, which operates at point b. This firm could reduce its input usage by moving to the frontier and operating at point a. Its distance function value is $D_s(y_s,x_s)$ = 0b/0a > 1. Likewise, the input distance function value for mutual firm m, operating at point e, is $D_m(y_m,x_m)$ = 0e/0d > 1.

The stock and mutual isoquants in Figure 1 have been drawn so that they intersect. This means that neither technology dominates the other for all combinations of inputs. The distance of the stock firm from the mutual frontier is $D_m(y_s,x_s)$ = 0b/0c < 1, and the distance of the mutual from the stock frontier is $D_s(y_m,x_m)$ =

0e/0f < 1, i.e., each firm is using an input vector that is dominant for its technology. If the isoquants do not intersect, e.g., if the stock-firm isoquant is to the left of the mutual-firm isoquant for all input combinations, then the stock technology is dominant for producing output level y. In this case, the $D_s(y_m,x_m)$ are always greater than 1.

Since technical efficiencies are obtained as reciprocals of input distance functions, these results imply that the group-specific efficiencies must be $\leq$ 1, i.e., a firm cannot do better than to operate on the frontier, but the cross-frontier efficiencies can be less than, equal to, or greater than 1. A cross-frontier efficiency greater than 1 means that a firm's input-output bundle is infeasible using the other group's technology. In terms of Figure 1, the output-input combination (y_s,x_s) is infeasible using the mutual technology and the output-input combination (y_m,x_m) is infeasible using the stock technology.

Under the managerial discretion and maturity hypotheses, one would expect to observe stock (mutual) firms operating in the region where stock (mutual) technology dominates. To measure dominance with respect to the production frontiers, we compute the distance between the frontiers for each firm in the sample. For example, for mutual firms we define the distance as:

$$F(y_m, x_m) = 1 - \frac{D_s(y_m, x_m)}{D_m(y_m, x_m)} = 1 - \frac{T_m(y_m, x_m)}{T_s(y_m, x_m)} \tag{8}$$

For the mutual firm portrayed in Figure 1, $F(y_m,x_m)$ = 1-0d/0f = (0f-0d)/0f, which provides a measure of the distance between the frontiers expressed as a ratio to the quantity of inputs required to produce the firm's output vector under the stock technology.[9] Likewise, for the stock firm in Figure 1, $F(y_s,x_s)$ = (0a-0c)/0c. A value of $F(y_i,x_i) < 0$ implies that the stock technology is dominant for input-output vector (y_i,x_i), while a value of $F(y_i,x_i) > 0$ implies that the mutual technology is dominant for this input-output vector.

We define a similar dominance measure based on cost efficiency:

[9]Because we are interested primarily in the sign of $F(x_i,y_i)$, the conclusions would be the same if we normalized the frontier distance to the input quantity needed to produce y_i under the mutual technology.

$$F_c(y_m, x_m) = 1 - \frac{C_m(y_m, x_m)}{C_s(y_m, x_m)} \tag{9}$$

where $F_c(y_m,x_m)$ = a scaled measure of the mutual firm's efficiency relative to the stock cost frontier minus its efficiency relative to the mutual cost frontier. If $F_c(y_i,x_i) < 0$, the stock frontier is dominant for input-output bundle (y_i,x_i); and if $F_c(y_i,x_i) > 0$, the mutual frontier is dominant for input-output bundle (y_i,x_i). Intuitively, if the mutual firm, for example, has higher efficiency with respect to its own frontier than it does with respect to the stock frontier, it would have to improve more to become fully efficient relative to the stock frontier, and thus a stock firm producing its output vector would be more efficient.

Estimating Efficiency Using DEA. DEA efficiency is estimated by solving linear programming problems. For example, the technical efficiency with respect to the pooled frontier is estimated by solving the following problem, for each firm, i = 1,2,... S+M, in each year of the sample period (time superscripts are suppressed):

$$\begin{aligned}
(D_p(y_i, x_i))^{-1} &= T_p(y_i, x_i) \\
&= \min \theta_i \\
\textit{subject to:} \quad Y_p \lambda_i &\geq y_i \\
X_p \lambda_i &\leq \theta_i x_i \\
\lambda_i &\geq 0
\end{aligned} \tag{10}$$

where $\mathbf{Y_p}$ is an N x (S+M) output matrix and $\mathbf{X_p}$ an K x (S+M) input matrix for all firms in the sample, $\mathbf{y_i}$ is a N x 1 output vector and x_i an K x 1 output vector for firm i, and λ_i is an (S+M) x 1 intensity vector (the inequalities are interpreted as applying to each row of the relevant matrix). Efficiencies for the stock and mutual samples, $T_s(x_s,y_s)$ and $T_m(x_m,y_m)$ are estimated similarly. The constraint $\lambda_i \geq 0$ imposes constant returns to scale.

The cross-frontier efficiencies of stock firms with respect to the mutual reference set are estimated by solving the following linear programming model, for each stock firm, s = 1,2,... S, and each time period:

$$(D_m(y_s, x_s))^{-1} = T_m(y_s, x_s) \tag{11}$$

$$= \min \theta_s$$

subject to: $Y_m \lambda_s \geq y_s$,

$X_m \lambda_s \leq \theta_s x_s$,

$\lambda_s \geq 0$,

where $\mathbf{Y}_m$ is an N x M output matrix and $\mathbf{X_m}$ an K x M output matrix for all *mutual* firms, $\mathbf{y}_s$ is an N x 1 output vector and $\mathbf{x}_s$ a K x 1 input vector of the *stock* firm s, and λ_s an M x 1 intensity vector of mutuals with respect to stock firm s. The efficiency $D_s(y_m,x_m)$ is estimated similarly.

For technical efficiency, we estimate two input distance functions (D_s (x_s,y_s) and D_m (x_s,y_s)) for 206 stock firms and two input distance functions (D_m (x_m,y_m) and D_s (x_m,y_m)) for 211 mutual firms. The pooled distance function $D_p(x_p,y_p)$ is also estimated to test our first null hypothesis.

A two-step procedure is used to estimate cost efficiency. Using the pooled reference set as an example, the first step is to solve the following problem:

$$\underset{x_i}{Min} \quad w_i^T x_i \tag{7}$$

subject to: $Y_p \lambda_i \geq y_i$,

$X_p \lambda_i \leq x_i$,

$\lambda_i \geq 0$.

The solution vector x_i* is the cost-minimizing input vector for the input price vector w_i and the output vector y_i. In the second step, we calculate firm i's cost efficiency as the ratio $\eta_i = w_i^T x_i^* / w_i^T x_i$.

The following problem is solved as the first step to obtain cross-frontier cost efficiencies of mutual firms with respect to the stock frontier:

$$\underset{x_m}{Min} \quad w_m^T x_m \tag{7}$$

subject to: $Y_s\lambda_m \geq y_m$,

$X_s\lambda_m \leq x_m,$

$\lambda_m \geq 0,$

where Y_s and X_s are output and input matrices for all stock firms and y_m and x_m are output and input vectors for mutual firm m, m = 1, 2, . . ., m, and λ_m is an intensity vector for stocks relative to the mutual firm. The solution vector x_m^* is the cost-minimizing input vector for mutual firm m with respect to the stock reference set. The second step is to calculate cost efficiency $\eta_m = w_m^T x_m^* / w_m^T x_m$. We estimate the same number of the cost efficiency measures as technical efficiency measures.

3. Outputs, Inputs, and Sample Selection

To estimate our input oriented distance and cost functions, we need estimates of outputs, inputs, and input prices. This section defines these variables and discusses the sample used to estimate the models.

Defining and Measuring Output. Consistent with most of the recent financial institutions literature we adopt a modified version of the value-added approach to measure property-liability insurer outputs. The value-added approach counts as important outputs those that have significant value added, as judged using operating cost allocations (see Berger and Humphrey, 1992).

Property-liability insurers provide three principal services:

- **Risk-pooling and risk-bearing.** Insurance provides a mechanism for consumers and businesses exposed to property-liability losses to engage in risk reduction through pooling. The actuarial, underwriting, and related expenses incurred in pooling are major components of value added in the industry. Insurers also add value by holding capital to bear the residual risk of the pool.

- **"Real" financial services relating to insured losses.** Insurers provide a variety of real services for policyholders including risk surveys, coverage design, loss prevention, and loss settlement services. By contracting with insurers to provide these services, policyholders can take advantage of insurers' specialized expertise to reduce costs associated with insurable risks.

- **Intermediation.** Insurers collect premiums in advance of loss payments and hold the funds in reserves until claims are paid, similar to corporate debt. Policyholders receive a discount in their premiums to compensate for the opportunity cost of the funds held by the insurer. The borrowed funds are invested primarily in marketable securities.

In terms of operating costs, about 32% of total industry operating expenses are for loss settlement services, the primary real service provided by the industry (A.M. Best Company, 1994). About 66% of operating costs are accounted for by marketing and administrative costs. Some of these costs are attributable to real services but the majority, such as actuarial, underwriting, and administrative costs, are attributable to the risk-pooling function. The remaining 2% of operating expenses are absorbed by the intermediation function. A strict application of the value-added approach would identify risk pooling and real services as important outputs and intermediation as an unimportant output. However, in view of the amount of assets controlled by insurers (about $705 billion in 1994) and the importance of investment income as a source of revenue for the industry, we elected to retain the intermediation function in defining industry output.

Transactions flow data such as the number of applications processed, the number of policies issued, the number of claims settled, etc. are not publicly available for insurers. However, a satisfactory proxy for the amount of risk-pooling and real insurance services provided is the present value of real losses incurred (Berger, Cummins, and Weiss, 1996).[10] Losses incurred are defined as the losses that are expected to be paid as the result of providing insurance coverage during a particular period of time. Because the objective of risk-pooling is to collect funds from the policyholder pool and redistribute them to those who incur losses, proxying output by the amount of losses incurred seems quite appropriate. Losses are also a good proxy for the amount of real services provided, since the amount of claims settlement and risk management services also are highly correlated with loss aggregates.

Because underwriting risk and service intensity vary by line of business, we disaggregate losses into four categories: short-tail personal lines, short-tail commercial lines, long-tail personal lines, and long-tail

[10]The use of premiums would not be appropriate because premiums represent price times quantity of output, i.e., insurance revenues.

commercial lines.[11] Because insurers report their losses incurred at undiscounted values, we discount the losses to present value using estimated industry-wide payout patterns.[12] Losses are deflated to the base year 1982 using the Consumer Price Index (CPI).

Our modeling of the intermediation function views insurers as raising funds by borrowing from policyholders and then investing the funds in marketable securities. The output of the intermediation function is total invested assets, expressed in real 1982 dollars by deflating by the CPI.

Defining and Measuring Inputs and Input Prices. Insurance inputs can be classified into four groups: labor, business services, debt capital (including policyholder funds), and equity capital. Our labor costs variable is the sum of salaries, employee benefits, payroll taxes, and miscellaneous employment-related costs. The quantity of labor input is defined as labor costs divided by a salary deflator, which indexes average weekly employee wages for Standard Industrial Classification (SIC) Class 6331, Fire, Marine, and Casualty Insurers. The salary deflator is interpreted as the price of labor input. The business services category is dominated by outside business services such as agents' commissions and loss adjustment expenses from lawyers and loss adjustment firms. Less important components of the materials category are travel, communications, and printing.[13] The input price index for business services is calculated similarly to the labor price index using SIC 7399, Business Services.

The debt capital of insurers consists primarily of funds borrowed from policyholders. These funds are measured in real terms as the sum of loss reserves and unearned premium reserves, deflated to the base year

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[11]The designations "long-tail" and "short-tail" refer to the length of the lag between the policy inception and loss payment dates. In short-tail lines (e.g., auto collision) the lag is usually less than two years, while for long tail lines (e.g., commercial liability) losses may remain unpaid for 10 or 15 years.

[12]Payout patterns are estimated from data reported in *Best's Aggregates and Averages* (A.M. Best Company, Oldwick, NJ, various years). We estimate the payout proportions using the method prescribed by the Internal Revenue Service for obtaining the present value of losses for tax purposes. The discount rates are based on the U.S. Treasury yield curves reported by Coleman, Fisher, and Ibbotson (1989), updated through 1990 using data from other sources.

[13]The costs of physical capital (mainly rental expenses and computers) are small relative to the other inputs. Accordingly, physical capital is incorporated into the materials category.

1982 using the CPI. The interest payment made to policyholders for the use of policyholder-supplied debt capital is implicit in the premium. The cost of policyholder-supplied debt capital is estimated as the ratio of total expected investment income minus expected investment income attributed to equity capital divided by average policyholder-supplied debt capital.[14]

Equity capital is an input for the risk-pooling and risk-bearing function because it provides assurance that the company will pay claims even if they are larger than expected. Thus, the real value of equity capital (deflated to 1982 by the CPI) is considered an input category. The cost of equity capital is estimated as the ratio of the insurer's expected net income to the average value of equity capital.[15] To summarize, we use four inputs: labor, materials, policyholder supplied debt capital, and equity capital.

Sample Selection. The primary source of data for this study are the regulatory annual statements filed with state insurance commissioners as reported on the A.M. Best Company data tapes. In order to estimate the evolution of efficiency and technical change in the industry, we selected a complete panel of insurers with data continuously available over the sample period, 1981-1990. The decision making units (DMUs) in the insurance industry consist of groups of affiliated insurers under common ownership and individual, unaffiliated insurers. The sample consists of all groups and unaffiliated insurers for which meaningful data were available over the entire sample period -- 206 stock insurers and 211 mutuals. The insurers in the sample accounted for 90 percent of industry assets during our sample period, so our results may be considered as reasonably

[14]Expected investment income attributable to equity capital equals the expected rate of investment return multiplied by average equity capital for the year. This is based on the Myers and Cohn (1987) argument that investors will not supply capital to an insurer unless they receive a market return equal to the amount they could receive by investing in an asset portfolio that replicates the insurer's portfolio plus a risk premium for costs arising due to committing capital to the insurance business.

[15]Since net income tends to fluctuate due to the randomness of loss payments, we computed the expected cost of capital as the predicted value of the ratio of adjusted net income to adjusted equity from a pooled cross-section time-series regression of this variable on a vector of variables representing insurer characteristics. Regressors include the proportions of bonds and stocks in the investment portfolio, the four insurance outputs, a measure of insurance leverage (the premiums-to-surplus ratio), the intermediate-term government bond yield, and year dummy variables. The predicted value from the regression was used as the cost of the equity capital input. The net income measure used in the ratio was adjusted for prepaid expenses.

representative of the entire industry.

Summary statistics on the variables used in estimating the models are presented in Table 1. Stock firms on average are larger than mutuals in terms of costs, input quantities, output quantities, and real invested assets. Stocks also produce more commercial lines output than mutuals; commercial lines account for 53 percent of insurance output for stock insurers but only 25 percent for mutuals. For mutuals, long-tail personal lines such as private passenger auto liability represent 51 percent of their insurance outputs. These patterns of business mix are consistent with the managerial discretion and maturity hypotheses. Also consistent with the managerial discretion hypothesis, stocks on average have lower geographical Herfindahl indices than mutuals, where the indices are based on the proportions of net premiums written by state.

4. Results

Average Efficiencies

Our first null hypothesis is that stocks and mutuals are operating on the same frontier, i.e., that a pooled frontier can be used to analyze differences in efficiency between the two organizational forms. The test involves estimating the pooled frontier as well as the group-specific mutual and stock frontiers and then testing the hypothesis that the pooled and group-specific frontiers are identical. Statistical tests overwhelmingly reject the hypothesis that the mutual frontier is identical to the pooled frontier based on the input distance function results.[16] The tests did not lead to rejection of the hypothesis that the stock frontier differs from the pooled frontier.[17] Nevertheless, the strong rejection with respect to mutuals implies that technical efficiency comparisons should be based on separate mutual and stock frontiers.

The technical efficiency scores based on separate mutual and stock frontiers are shown in the columns

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[16]The test is discussed in Elyasiani and Mehdian (1992), and the results are available from the authors.

[17]Although this would seem to suggest that stocks are defining the pooled frontier, in fact that does not appear to be the case. Although stocks appeared slightly more often in reference sets (344 times in the ten years covered in the study) than mutuals (314 times), the difference is not statistically significant. The reference set is the group of firms that form the frontier for a specific insurer (the firms with non-zero λ_i in the linear programming solution).

headed $T_s(y_s,x_s)$ and $T_m(y_m,x_m)$ in Table 2.[18] Mutuals are significantly more efficient with respect to the mutual frontier, in comparison with the efficiency of stocks relative to the stock frontier, in every year of the sample period; and the dispersions of the mutual efficiency scores within each year of the sample period are lower than the dispersions of the stock scores. The findings with respect to both average efficiencies and dispersions would be consistent with stocks' operating in more complex and heterogeneous lines of business as predicted by the managerial discretion hypothesis. Efficiencies might be lower in complex lines because it is easier to make mistakes in designing technologies for underwriting, pricing, and servicing complicated or individualized insurance policies. These results cannot be interpreted as implying that the output of stock insurers would be produced more efficiently by mutuals, however, because the firms are using different technologies, reflected in different production frontiers.

We also compute the technical efficiencies of the mutuals relative to the stock frontier and the technical efficiencies of stocks relative to the mutual frontier, i.e., the *cross-frontier efficiencies*. This provides evidence on our second major null hypothesis, that each group of firms is dominant on average in producing the output vectors chosen by members of the group. These results are shown in the columns of Table 2 headed $T_m(y_s,x_s)$ and $T_s(y_m,x_m)$, respectively. The stock relative-to-mutual-frontier average scores ($T_m(y_s,x_s)$) are consistently greater than 1, implying that it is not feasible, on average, to replicate stock input-output combinations using the mutual technology. Or, in other words, the stock technology dominates mutual technology for producing the stock firms' output vectors. The mutual technical efficiencies with respect to the stock frontier ($T_s(y_m,x_m)$) are also greater than 1 in 8 of 10 years and on the average, although the mutual-to-stock-frontier scores are lower than the stock-to-mutual-frontier scores. The implication is that mutual technology weakly dominates stock technology in producing the mutual output vectors.

[18] Asterisks between pairs of columns give the results of significance tests for differences between the results in the corresponding cells of the two columns. Reported significance levels are based on analysis of variance (ANOVA). Non-parametric tests, including the Kruskal-Wallis, Van der Waerden, and Savage tests, produced similar results.

The significance tests reported in the last two columns of Table 2 show that stock technical efficiencies relative to the stock frontier are significantly lower than stock efficiencies relative to the mutual frontier, providing further evidence that the stock technology is dominant in producing the stock output vectors. Likewise, mutual efficiencies relative to the mutual frontier are consistently and significantly lower than mutual efficiencies relative to the stock frontier, again suggesting that the mutual technology is dominant in producing mutual output vectors.

The cost efficiency results are shown in Table 3. Statistical testing led to the strong rejection of the null hypotheses that the stock and mutual frontiers are identical to the pooled frontier. Consequently, we focus on the stock and mutual frontier results. The cost efficiencies for the stock and mutual samples based on their respective frontiers are shown in the first and second data columns of Table 3, headed $C_s(y_s,x_s)$ and $C_m(y_m,x_m)$, respectively. For the sample period as a whole, mutual efficiency averaged 68.2 percent, while stock efficiency averaged 61.7 percent. These results imply that mutuals could have reduced their costs by 31.8 percent, on average, if they had been operating with full efficiency, and that stocks could have reduced their costs by 38.3 percent; but, as above, the results are not correctly interpreted as suggesting that mutuals are more cost efficient than stocks.

The cross-frontier cost efficiency comparisons are presented in the columns headed $C_m(y_s,x_s)$ (stocks compared to the mutual frontier) and $C_s(y_m,x_m)$ (mutuals compared to the stock frontier). None of the individual year averages of $C_m(y_s,x_s)$ or $C_s(y_m,x_m)$ exceeds 1, implying that both stocks and mutuals on average operate inside of both cost frontiers.

The efficiencies of the stocks relative to the mutual frontier ($C_m(y_s,x_s)$) are significantly higher than the efficiencies of the stocks relative to the stock frontier ($C_s(y_s,x_s)$) in nine of ten years and overall, paralleling the technical efficiency results, and implying that the stock cost frontier dominates the mutual frontier for the stock firms' output vectors. However, average cost efficiencies of mutuals relative to the stock frontier ($C_s(y_m,x_m)$) are significantly *lower* than the efficiencies relative to the mutual frontier ($C_m(y_m,x_m)$) during the first four years of the sample period and overall. Mutual efficiencies relative to the stock frontier are significantly higher than their efficiencies relative to the mutual frontier in only one year (1988). These results suggest that the stock frontier tends to dominate the mutual frontier in terms of cost efficiency. Thus, even though the mutual technology tends to be superior to the stock technology on the average, the technological advantage does not carry through into cost efficiency. This finding is explored in more detail in the following section.

The difference between the cost results shown in Table 3 and the technical efficiency results shown in Table 2 primarily reflects allocative efficiency. Allocative efficiency problems are often interpreted as evidence of expense preference behavior, i.e., management is over-consuming some inputs and under consuming others. Allocative efficiency for stock insurers averaged 70 percent during our sample period, compared to 74 percent for mutuals, with both comparisons based on group-specific frontiers, suggesting that there is considerable slippage in efficiency due to the failure to choose the cost-minimizing combination of inputs for both groups of firms.[19]

To summarize, the technical efficiency results presented in this section imply that stocks and mutuals are using different technologies and that the stock (mutual) technology is superior on average to the mutual (stock) technology for producing the stock (mutual) firms' output vectors. This is consistent with the managerial discretion hypothesis. However, the stocks' comparative advantage in producing stock outputs exceeds the mutuals' comparative advantage in producing mutual outputs. This is as expected if the stock firms are engaged in more complex operations where technical superiority is important.[20] Both types of firms

[19]Because there is no natural interpretation of cross-frontier allocative efficiency, we do not have cross-frontier results for this type of efficiency. Because allocative efficiency is computed as the ratio of cost efficiency (C) to technical efficiency (T), the rejection of the common frontiers hypothesis for both technical and cost efficiency implies that allocative efficiency too should be evaluated relative to the stock and mutual frontiers.

[20]Our estimates of economies of scale indicate that 52 percent of stocks and 61 percent of mutuals are operating at constant returns to scale and that almost all of the remaining firms operate at decreasing returns to scale (average results for the period as a whole). Thus, the smaller technological advantage of mutuals over stocks in producing mutual outputs in comparison to the technological advantage of stocks over mutuals in producing stock outputs does not appear to be attributable to mutuals' being less likely to operate at the optimum scale.

experience erosion of their technological advantage due to suboptimal input combinations (allocative inefficiency). For stocks, allocative inefficiency reduces but does not eliminate their comparative advantage in producing stock output combinations. However, due to the smaller technological advantage of mutuals, allocative inefficiency leads to dominance of the mutual cost frontier by the stock cost frontier for the mutuals' output combinations. Thus, overall, the mutual form of ownership is inferior to the stock form of ownership in terms of cost minimization.

Cross-Frontier Efficiency: Further Analysis

In this section we conduct further analysis of the cross-frontier efficiency results using the statistics $F(y_i,x_i)$ and $F_c(y_i,x_i)$ defined in equations (8) and (9). Recall that if $F(y_i,x_i) < 0$ ($F_c(y_i,x_i) < 0$) for output-input vector (y_i,x_i), then the stock production (cost) frontier dominates the mutual frontier for that output-input combination, and if $F(y_i,x_i) > 0$ ($F_c(y_i,x_i) > 0$) , the mutual production (cost) frontier dominates the stock frontier for that input-output combination. We conduct two additional analyses. First, we investigate frontier dominance by size quartile for the firms in the sample to determine whether the same conclusions about frontier dominance hold for firms in various size categories. And, second, we conduct a regression analysis to test predictions of the managerial discretion and maturity hypotheses.

The quartile results are presented in Table 4, which shows $F(y_i,x_i)$ and $F_c(y_i,x_i)$ for each size group as well as significance tests of the null hypothesis that the averages are equal to zero. The results in the production frontiers section of Table 4 confirm our inference that stock technologies are superior in producing stock output vectors and mutual technologies are superior in producing mutual output vectors. Stock superiority exceeds that of mutuals in all size quartiles, and for both organizational forms technical dominance is declining in size. The results in the cost frontier section of Table 4 show that the average values of $F_c(y_i,x_i)$ are significantly less than zero for all four size quartiles and both organizational forms.[21]

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[21]The percentages of stock firms in quartiles 1 through 4, respectively, with $F(x_i,y_i) < 0$ are 71.9%, 71.2%, 74.2%, and 70.6%; and the percentages of mutuals in quartiles 1 through 4, respectively with $F(y_i,x_i) < 0$ are 59.6%, 60.1%, 65.7%, and 57%. Quartile 1 is the smallest size quartile.

The managerial discretion hypothesis predicts that mutuals are likely to have a comparative advantage in personal lines such as private passenger auto insurance where the need for managerial discretion is low. In addition, the maturity hypothesis predicts that mutuals will have a comparative advantage in long-tail lines because the owner-policyholder conflict is relatively strong in such lines. To analyze the comparative advantages of the stock and mutual ownership forms by line of business, we regress $F(y_i,x_i)$ and $F_c(y_i,x_i)$, respectively, on a set of independent variables representing organizational form, size, and business mix.

The regression results are presented in Table 5. Three models are presented for both the technical and the cost measures of frontier dominance. The first model (Model 1) includes a dummy variable for the stock form of ownership (STOCK = 1 if the firm is a stock insurer, 0 otherwise), dummy variables representing the second, third, and fourth size quartiles (the first quartile is the smallest), interaction terms between the organizational form and size dummies, and the proportion of total insurance output in the long-tail commercial lines (LTC%), short-tail personal lines (STP%), and short-tail commercial lines (STC%). The second model (Model 2) adds interaction terms between the organizational form variable (STOCK) and the business mix variables to allow the effects of organizational form to differ by line of business. The third model (Model 3) adds interactions between the business mix variables and size, where size is measured by the log of total insurance output, and between business mix, size, and organizational form. We use a continuous measure of size for the interactions to conserve on the number of terms added to the regressions.

The comparative advantage of the two ownership forms by line of business is seen most clearly in Model 2 by considering the interactions between the business mix variables (LTC%, STP%, and STC%) and the dummy variable STOCK in both the technical and cost sections of the table. The omitted category is LTP%*STOCK, reflecting the proportion of insurance output in the long-tail personal lines category.[22] The negative coefficients on the stock organizational form/business mix interaction terms imply that stocks tend to have a comparative advantage in writing these lines relative to long-tail personal lines in the sense that a

[22]Model 3 leads to the same conclusion but requires the evaluation of another set of coefficients.

marginal increase in the proportion of business in these lines tends to shift the stock frontier to the left of the mutual frontier. This is consistent with the agency theoretic prediction that mutuals tend to do relatively well in long-tail personal lines. The fact that the coefficient on the long-tail commercial/stock interaction term (LTC%*STOCK) is lower (in absolute value) than the coefficient on the short-tail commercial/stock interaction (STC%*STOCK) in the technical dominance version of model 2 is consistent with the argument that the comparative advantage of stocks is relatively low in long-tail lines (these coefficients are about the same in the cost version of model 2) . It is perhaps somewhat surprising that the coefficient on the short-tail personal/stock interaction (STP%*STOCK) is negative and significant. However, this can be viewed as reinforcing the inference that the advantage of mutuals is especially significant in long-tail lines.

Productivity Change

The Malmquist indices enable us to measure productivity change for stock and mutual insurers during our sample period. Based on the Malmquist analysis, we decompose productivity growth into efficiency change and technical change components. Favorable efficiency change is interpreted as evidence of "catching-up" to the frontier, while favorable technical change is interpreted as innovation.

The Malmquist productivity analysis is presented in Table 6. The results shown are geometric means of the Malmquist indices and its components for the firms in the sample (see Grifell-Tatjé and Lovell, 1996) based on separate stock and mutual frontiers. Recall that technical efficiency measures the reciprocal of the distance of firms from the frontier and that technical efficiency change measures the evolution of this distance over time. If the technical efficiency index exceeds 1.0, firms on average have moved closer to the frontier, and if less than 1.0, firms on average have moved further from the frontier. The second component of the Malmquist index, measures movement in the frontier over time (technical change). If this component of the index exceeds 1.0, the implication is that technical innovation has occurred, while a value less than 1.0 implies technical regress. The Malmquist index itself measures total factor productivity, i.e., a value greater than 1.0 shows productivity growth, while a value less than 1.0 implies productivity decline.

Table 6 shows the year-to-year technical efficiency change and technical change indices. For both stocks and mutuals, technical efficiency and technical change indices fluctuate in a narrow range about 1.0, and the geometric mean of the year-to-year changes in the Malmquist index and its two components also is close to 1.0. Analysis of variance tests reveal virtually no significant differences between stocks and mutuals in efficiency change, technical change, or total factor productivity growth. Thus, the technical efficiency and productivity changes over the period were not dramatic and did not vary significantly by organizational form. The slight increase in technical change is very likely due to improvements in computer and communications technology, while the slight decline in efficiency may reflect the difficulty that some firms have had in adapting to the new technology. These results reinforce our earlier findings that the most significant differences between stocks and mutuals arise in comparisons of cost efficiency and also reinforces the inference that slippages due to allocative inefficiency account for the dominance of the mutuals by the stocks in terms of cost efficiency.

5. Conclusions

In this paper, we test three agency theoretic hypotheses about stock and mutual organizational forms in the property-liability insurance industry: (1) The managerial discretion hypothesis, which predicts that stock insurers have a comparative advantage in lines of insurance where relatively high levels of managerial discretion are required because the stock ownership form affords superior mechanisms for owners to monitor and control managers; (2) the maturity hypothesis, which predicts that mutuals have a comparative advantage in lines of insurance with relatively long payout periods because the owners' incentive to exploit policyholder interests is eliminated by merging the owner and policyholder functions in the mutual ownership form; and (3) the expense preference hypothesis, which predicts that mutuals will be less efficient than stocks because the weaker mechanisms for controlling owner-manager conflicts in the mutual ownership form permit managers to engage in excessive consumption of perquisites. The first two hypotheses imply that the mutual and stock forms of ownership represent different technologies for producing insurance, where technology is defined as all of the contractual relationships comprising the firm as well as physical technology choices.

This paper provides evidence on these hypotheses by estimating the technical and cost efficiency of a sample of stock and mutual property-liability insurers representing almost 90 percent of industry revenues over the period 1981-1990. We first test the hypothesis that the mutual and stock ownership forms represent different technologies by testing whether pooled technical and cost frontiers are identical to group-specific frontiers, where mutual efficiencies are measured with mutuals as the reference set and stock efficiencies are measured with stocks as the reference set. The hypotheses that the two groups of firms are operating on the same production and cost frontiers are strongly rejected. This finding supports the agency theoretic arguments because it implies that the two organizational forms are utilizing distinct technologies.

We also seek stronger evidence regarding the managerial discretion, maturity, and expense preference hypotheses by conducting cross-frontier efficiency estimations where each stock (mutual) firm's efficiency is measured relative to a reference set consisting of all mutual (stock) insurers. By comparing the cross-frontier estimates with the group-specific frontier estimates, we can determine which technology (mutual or stock) is dominant for producing each output vector observed in our sample. If a specific firm's efficiency score relative to its group-specific frontier is greater than its cross-frontier efficiency score, then its group's technology is dominated by the technology of the other group in the production of its outputs. Intuitively, this firm would have to improve more to achieve full efficiency using the alternative technology than to achieve full efficiency using its own technology.

The analysis of <u>production frontiers</u> implies that the mutual frontier dominates the stock frontier for producing the mutual firms' output vectors, while the stock frontier dominates the mutual frontier for producing the stock firms' output vectors. This supports the managerial discretion and maturity hypotheses because it implies that the two organizational forms have been sorted into activities where they have comparative technological advantages. Regression analysis reveals that mutuals have a comparative advantage in writing long-tail personal lines, providing further support for these two hypotheses.

Analysis of <u>cost frontiers</u>, on the other hand, shows that the stock technology tends to dominate the mutual technology in terms of cost efficiency not only for stock firms but also for mutuals. Cost efficiency encompasses both technical efficiency and allocative efficiency, where the latter measures the firm's success in employing the cost-minimizing combination of inputs. Thus, taken together, the production and cost frontier results suggest that mutuals have developed a superior technology for producing their output vectors but that this advantage is dissipated for many mutuals because of their failure to minimize costs. Although the stock firms' technological advantage is also eroded due to allocative inefficiency, their greater relative superiority in technical efficiency allows the stocks' cost frontier to be dominant for both types of firms. The dominance of the stocks in terms of cost efficiency provides support for the expense preference hypothesis.

Our findings suggest a richer interpretation of organizational form in insurance markets than provided by previous researchers. The sorting of stock and mutual firms into market segments where they have comparative advantages and the long-term coexistence of the two types of firms are not necessarily inconsistent with the mutuals' being less successful than stocks in minimizing costs. Search costs (Dahlby and West, 1986), slow diffusion of information in insurance markets (Berger, Kleindorfer, and Kunreuther, 1989), and private information (D'Arcy and Doherty, 1991) provide possible explanations for the survival of less efficient mutuals.

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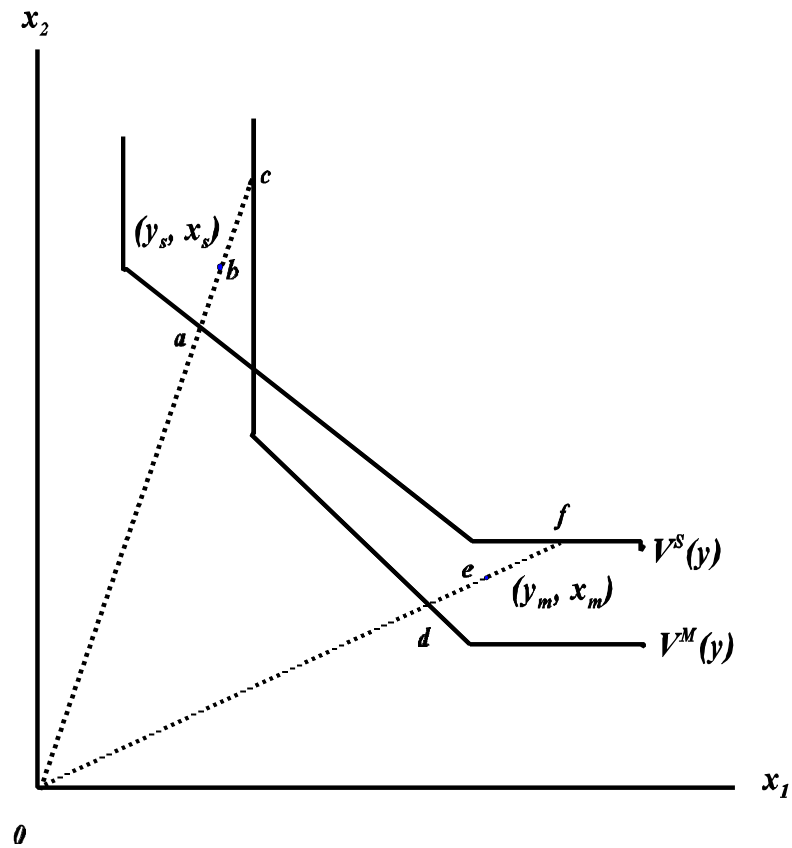
Figure 1

Stock and Mutual Production Frontiers and Input Distance Function Under Constant Returns to Scale



$$D_s(y_s, x_s) = 0b/0a > 1$$
$$D_m(y_s, x_s) = 0b/0c < 1$$
$$D_m(y_m, x_m) = 0e/0d > 1$$
$$D_s(y_m, x_m) = 0e/0f < 1$$

Table 1
Summary Statistics for Stock and Mutual Samples

Variable Definition	Sample Means: Pooled	Stock		Mutual
Number of Firms	417	206		211
Total Cost	177.2	247.6	*	114.3
Price of labor input	0.986	0.986		0.986
Price of materials input	1.218	1.218		1.218
Price of equity capital input	0.0970	0.1011	*	0.0935
Price for policyholders' funds	0.0614	0.0613		0.0615
Labor input	34.3	46.3	*	23.5
Materials input	76.3	107.6	*	48.3
Equity capital input	185.1	241.9	*	134.2
Policyholders' debt capital input	413.0	608.1	*	238.4
Short tail personal lines output	29.9	29.8		30.0
Short tail commercial output	25.8	41.7	*	11.5
Long tail personal lines output	68.3	72.9		64.3
Long tail commercial lines output	46.1	75.1	*	20.2
Short tail personal lines price	0.645	0.718	*	0.582
Short tail commercial price	0.863	0.801	**	0.917
Long tail personal lines price	0.646	0.596	*	0.689
Long tail commercial lines price	1.094	1.013	*	1.164
Real invested assets	506.8	701.8	*	332.2
Return on assets	0.033	0.027		0.038
Herfindahl index (geographic: by state)	0.589	0.527	*	0.644
Herfindahl index by line (direct premiums written)	0.440	0.461	**	0.421
Premiums-to-surplus ratio	1.846	1.939	*	1.763

Note: All output and input quantities are in millions of 1982 dollars. Output volume is the present value of real losses (1982 dollars).
*****Statistically significant difference between stocks and mutuals at the 1% level.
******Statistically significant difference between stocks and mutuals at the 5% level.

TABLE 2
TECHNICAL EFFICIENCY RESULTS: 1981-1990

Year	Ts(ys,xs)		Tm(ym,xm)	Tm(ys,xs)		Ts(ym,xm)	Ts(ys,xs) vs. Tm(ys,xs)	Ts(ym,xm) vs. Tm(ym,xm)
1981	0.8930	*	0.9400	1.3490	*	0.9920	*	*
	(0.105)		(0.073)	(0.967)		(0.228)		
1982	0.8910	*	0.9390	1.3010	*	1.0380	*	*
	(0.113)		(0.071)	(0.915)		(0.482)		
1983	0.8830	**	0.9050	1.2090	*	1.0220	*	*
	(0.121)		(0.088)	(0.756)		(0.393)		
1984	0.8880	***	0.9070	1.2180	***	1.0880	*	*
	(0.119)		(0.099)	(0.823)		(0.523)		
1985	0.8770	*	0.9310	1.3200	*	1.0520	*	*
	(0.118)		(0.083)	(0.958)		(0.617)		
1986	0.8690	*	0.9150	1.3900	*	1.0150	*	*
	(0.127)		(0.091)	(1.050)		(0.352)		
1987	0.8740	*	0.9290	1.3010	*	1.0170	*	**
	(0.125)		(0.077)	(0.956)		(0.544)		
1988	0.8750	*	0.9180	1.2690	*	1.0610	*	*
	(0.127)		(0.085)	(0.931)		(0.359)		
1989	0.8850	*	0.9130	1.1570		1.0660	*	*
	(0.113)		(0.086)	(0.713)		(0.505)		
1990	0.8710	*	0.9210	1.1720	*	0.9980	*	*
	(0.111)		(0.082)	(0.689)		(0.356)		
Mean	0.8804	*	0.9216	1.2669	*	1.0351	*	*
	(0.1185)		(0.0847)	(0.8841)		(0.4514)		

Numbers in parentheses are standard deviations.

NOTE: Tk = Technical Efficiency for frontier (reference set) k
k = s = stock frontier
k = m = mutual frontier
Xs, Ys = Input and output for stock firms, respectively
Xm, Ym = Input and output for mutual firms, respectively

*Statistically significant at 1 percent level or better; **statistically significant at the 5 percent level; ***statistically significant at the 10 percent level.

TABLE 3
COST EFFICIENCY RESULTS: 1981-1990

Year	Cs(ys,xs)		Cm(ym,xm)	Cm(ys,xs)		Cs(ym,xm)	Cs(ys,xs) vs. Cm(ys,xs)	Cs(ym,xm) vs. Cm(ym,xm)
1981	0.6265	*	0.7533	0.7871	*	0.6524	*	*
	(0.1974)		(0.1580)	(0.3009)		(0.1621)		
1982	0.6503	*	0.7415	0.7655	*	0.6621	*	*
	(0.1990)		(0.1550)	(0.2838)		(0.1662)		
1983	0.6255	*	0.7088	0.7355	*	0.6606	*	*
	(0.1989)		(0.1655)	(0.2813)		(0.1781)		
1984	0.5907	*	0.6625	0.7163	*	0.6297	*	***
	(0.1960)		(0.1772)	(0.3041)		(0.1828)		
1985	0.6346	**	0.6770	0.6882		0.6871	**	
	(0.2060)		(0.1624)	(0.2906)		(0.1915)		
1986	0.6166	*	0.6885	0.7171	***	0.6726	*	
	(0.1964)		(0.1700)	(0.3151)		(0.1995)		
1987	0.6328		0.6600	0.6956		0.6662	**	
	(0.2107)		(0.1773)	(0.3561)		(0.2087)		
1988	0.6090		0.5968	0.5924	*	0.6826		*
	(0.2039)		(0.1743)	(0.2665)		(0.2206)		
1989	0.5822	*	0.6659	0.6497		0.6600	**	
	(0.2186)		(0.1882)	(0.3072)		(0.2233)		
1990	0.6077	*	0.6632	0.6589		0.6639	**	
	(0.2089)		(0.1782)	(0.2992)		(0.2158)		
Mean	0.6172	*	0.6815	0.6997	*	0.6638	*	*
	(0.2043)		(0.1758)	(0.3054)		(0.1963)		

Numbers in parentheses are standard deviations.
NOTE: Ck = Cost Efficiency for frontier k
k = s = stock frontier
k = m = mutual frontier
ys, xs = Output and input for stock firms, respectively
ym, xm = Output and input for mutual firms, respectively
*****Statistically significant at 1 percent level or better; ****** Statistically significant at the 5 percent level;
*******Statistically significant at the 10 percent level.

TABLE 4
FRONTIER DIFFERENCES BY SIZE QUARTILE

		PRODUCTION FRONTIERS:		COST FRONTIERS:	
		STOCK	MUTUAL	STOCK	MUTUAL
QUARTILE 1	Mean	-0.770	0.090	-0.145	-0.023
	T-Test	-11.976	11.383	-10.702	-3.623
QUARTILE 2	Mean	-0.490	0.056	-0.159	-0.059
	T-Test	-11.305	8.159	-10.662	-7.471
QUARTILE 3	Mean	-0.324	0.036	-0.133	-0.063
	T-Test	10.208	5.285	-12.597	-9.543
QUARTILE 4	Mean	-0.204	0.026	-0.112	-0.034
	T-Test	-9.174	5.084	-17.275	-6.108

Note: Upper entries for each quartile and organizational form are averages of F(yi , xi) (production) and Fc(yi , xi) (cost). Lower entries are t-tests of the null hypothesis that averages are equal to zero. Quartile 1 = smallest size quartile.

TABLE 5: REGRESSION ANALYSIS: TECHNICAL AND COST DOMINANCE STATISTICS: 1981-1990

	TECHNICAL DOMINANCE: F(y,x)						COST DOMINANCE: $F_c(y,x)$					
	MODEL 1		MODEL 2		MODEL 3		MODEL 1		MODEL 2		MODEL 3	
YEAR	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio
Constant	0.3595	9.032	0.0826	1.875	0.0596	1.538	0.1304	10.684	0.0701	5.203	0.0487	3.820
DSIZE2	-0.0108	-0.321	-0.0394	-1.173	-0.0393	-1.049	0.0409	-3.963	-0.0613	-5.890	-0.0625	-5.074
DSIZE3	-0.0021	-0.062	-0.0614	-1.768	-0.0742	-1.558	-0.0342	-3.246	-0.0632	-5.880	-0.0770	-4.920
DSIZE4	0.0077	0.220	-0.0545	-1.488	-0.1002	-1.472	-0.0139	-1.292	-0.0502	-4.421	-0.0984	-4.400
STOCK	-0.6385	-15.843	-0.0212	-0.331	0.0711	1.045	-0.0341	-2.756	0.1084	5.477	0.0769	3.434
DISZE2*STOCK	0.1635	3.123	0.1136	2.192	-0.0153	-0.267	-0.0378	-2.353	-0.0298	-1.859	-0.0073	-0.386
DSIZE3*STOCK	0.3304	6.292	0.3202	6.139	0.1037	1.483	-0.0103	-0.639	0.0092	0.568	0.0495	2.153
DSIZE4*STOCK	0.4104	7.909	0.3794	7.213	0.0438	0.449	-0.0243	-1.529	-0.0036	-0.219	0.0825	2.576
LTC%	-0.1342	-3.555	0.1120	2.238	-0.1957	-0.600	-0.0771	-6.661	0.0072	0.462	-0.2537	-2.365
STP%	-0.9417	-14.830	-0.0225	-0.212	-0.9093	-1.280	-0.2997	-15.393	-0.0009	-0.028	-1.0576	-4.529
STC%	-0.6190	-14.818	0.0038	0.061	0.4098	0.957	-0.3453	-26.962	-0.2530	-13.067	0.0892	0.633
LTC%*STOCK			-0.4430	-5.956	-0.1620	-0.375			-0.1622	-7.044	0.2037	1.432
STP%*STOCK			-1.4689	-11.139	-4.5526	-5.301			-0.4657	-11.407	0.0252	0.089
STC%*STOCK			-1.0679	-12.943	-2.6371	-5.233			-0.1689	-6.612	0.1619	0.977
LTC%*Ln(Insout)					0.0206	0.986					0.0177	2.574
STP%*Ln(Insout)					0.0578	1.280					0.0668	4.497
STC%*Ln(Insout)					-0.0248	-0.908					-0.0223	-2.483
LTC%*Ln(Insout)*STK					-0.0138	-0.506					-0.0225	-2.507
STP%*Ln(Insout)*STK					0.2058	3.734					-0.0295	-1.628
STC%*Ln(Insout)*STK					0.1046	3.260					-0.0211	-1.999
Adjusted R_2	0.254		0.291		0.305		0.323		0.344		0.372	

Note: LTC% = proportion of insurance output in long-tail commercial lines; STP% = proportion of insurance output in short-tail personal lines; STC% = proportion of insurance output in short-tail commercial lines; DSIZE2 = 1 if insurer is in size quartile 2 (quartile 1 = smallest insurers), 0 otherwise; DSIZE3 = 1 if insurer is in size quartile 3, 0 otherwise; DSIZE4 = 1 if insurer is is in size quartile four, 0 otherwise; STOCK = STK = 1 if insurer is a stock insurer, 0 otherwise; Insout = total insurance outuput (1982 $, billions). Year dummies not shown.

TABLE 6
MALMQUIST PRODUCTIVITY INDICES:
EFFICIENCY CHANGE AND TECHNICAL CHANGE

	MUTUAL			STOCK		
Years	Malmquist Index	Efficiency Change	Technical Change	Malmquist Index	Efficiency Change	Technical Change
81-82	0.9907	0.9983	0.9924	1.0086	0.9981	1.0106
82-83	0.9712	0.9610	1.0106	1.0001	0.9858	1.0145
83-84	0.9964	0.9992	0.9972	1.0123	1.0071	1.0052
84-85	0.9920	1.0300 *	0.9631 **	0.9176	0.9845	0.9321
85-86	1.0423	0.9827	1.0606	1.0357	0.9915	1.0445
86-87	1.0445	1.0170	1.0271	1.0337	1.0062	1.0274
87-88	0.9932	0.9872	1.0061 **	1.0249	0.9996	1.0252
88-89	0.9784	0.9926	0.9857	0.9886	1.0152	0.9737
89-90	1.0208	1.0090	1.0118	0.9999	0.9832	1.0170
Geometric Means:	1.0030	0.9973	1.0057	1.0018	0.9967	1.0051

***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.